the City Asylum, and although the discovery was published without specified acknowledgment, and, in general language, by an asylum physician who made use of Dr. Kiernan's notes in the compilation of his paper, I think that the priority of discovery of this hitherto unknown complication of paresis belongs to Dr. Kiernan, who will shortly publish the details of his two cases in full.

Art. VII.—RESEARCHES ON THE SPINAL CORD.

By Isaac Ott, M. D.

THE spinal cord, besides being a conductor to and fro of nervous impulses, is also the seat of several nerve centres, administering to the functions mainly automatic. I shall consider in this paper only the practical bearing of certain points connected with the physiology of the spinal cord. These points have been worked out in the laboratory at Johns Hopkins University, and will be published in detail elsewhere.

SECRETORY FUNCTIONS.

That the spinal cord and medulla oblongata preside over the secretion of sweat has been shown by the researches of Luchsinger. These centres send out fibres in the cat through the anterior root of the fourth dorsal nerve, into the stellate ganglion, and then into the ulnar and median nerves to the skin of the anterior extremities. The sweat fibres for the posterior extremities run through the anterior root of the three last dorsal nerves into the abdominal sympathetic, and then into the sciatic. The anterior roots of the last lumbar and first sacral also send fibres into the sciatics. On the sweat glands are seated ganglia inhibiting the activity of the sweat secretion, and these ganglia are called into exaggerated activity by irritation of the fibres contained in the abdominal sympathetic. These inhibitory ganglia may serve to explain the phenomenon of a "hot non-sweating skin." Heat, ordinarily, is one of the greatest excitants of the sweat secretion, and ought to start the secretion in feverish states, unless there is some force inhibiting it. The most important question is, where is the seat of the sweat centres and the course of the sweat fibres in man? To decide this, pathology must be the field in which to find facts to elucidate these points.

SEAT OF SWEAT CENTRES.

Traube relates the following case, which has an important bearing on this point. Case I, R., aet. 51. Previously not sick, with the exception of an intermittent; a large, well-built frame, hearing good, no otorrhœa, no headache, both arms completely paralyzed and extended on the trunk, but could be passively bent at the elbows; the fingers, with the exception of the thumb, were bent into the hollow of the hand; there was complete anæsthesia, except about the shoulders; the lower extremities were like the arms, voluntarily immovable, bent at the knees, the tendons being on the stretch; reflex movements were able to be excited; the skin of both lower extremities without sensibility; skin of abdomen insensible; incomplete sensibility in the lower part of the thorax; sensibility of upper part of breast, throat and face undisturbed; no alteration in the sense of taste; no palsy of the face; urine passed involuntarily, and constipation existing.

In the last eight days before death he suffered from a great increase of sweat over the whole body. On autopsy the brain and medulla oblongata were intact, but about half an inch below the medulla the spinal cord was very soft, and three and a half inches below the pons the consistence was extremely small, the nerve substance being completely broken up. This part was strongly compressed by a tumor the size of a pigeon's egg, and attached to the anterior wall of the spinal dura mater by the anterior surface, whilst the posterior convex surface projected into the cavity of the spinal canal and against the anterior columns, without being connected with them. In the vicinity of the seventh cervical vertebra there was a very considerable softening, which was of greatest intensity upwards for about two inches. On a transverse section of the upper part of the cervical portion of the spinal cord, the surface was somewhat pale. In the softer parts the substance issued forth in a profuse manner, most so in the vicinity of the fourth cervical vertebra, but even here the pale red grey substance could be well distinguished from the jelly-white substance. The remainder of the cord was normal.

This case proves that in man a nutritive lesion in the cervical part of the cord can call the sweat centres below it into exaggerated activity. In a case of progressive muscular atrophy under my care, where the disease had extended to the medulla oblongata and was accompanied with profuse salivation, I noticed on the face an augmented amount of sweat, which indicated that the sweat centres extended up into the medulla oblongata. Further, there are several cases on record where a myelitis has abolished sweating below its seat. Thus, Mr. C., who had a localized myelitis in the dorsal region, with complete loss of sensation and voluntary motion, no sweating was observed in the lower extremities till voluntary motion and sensation returned. As to the path of the sweat fibres in man, pathological changes afford brilliant evidence. Thus, Dr. Pepper reports the following cases:

Case II. A patient was under observation for eighteen months, suffering with an abdominal tumor of either an aneurismal or cancerous nature. One of the symptoms most constantly complained of was profuse sweating, so that although he was a cleanly person an unpleasant exhalation could not be prevented. It is a remarkable fact that, by the patient altering his position, so as to alter the pressure, the sweating could be confined to one side.

Case III. Dr. A. H. Smith, patient, reported by Dr. Pepper. The person had an encephaloid cancer of the abdominal lymphatic glands, at a point behind the pancreas and corresponding to the seat of the solar plexus of the sympathetic. The diseased glands formed a large flattened mass, closely adherent to the vertebral column posteriorly, and to the pancreas anteriorly, although it was impossible, owing to the circumstances of the autopsy, to make a careful dissection of the nervous ganglia involved in or pressed upon by the cancerous mass. Here profuse sweating existed.

These cases give ample proof that in man the sweat fibres run in the abdominal sympathetic, and that, reflexly, they can call out perspiration in other parts of the body.

When we examine the course of the sweat fibres in the thorax, we find that some run in the sympathetic. Thus, Case IV.,* a cachectic individual, had either an aneurismal or malignant tumor at the base of the neck, which had grown up from within the thorax. The tumor was on the right side, and accompanied with profuse unilateral sweating on the right side of head, terminating abruptly at the median line. The right pupil was also contracted, and no thermometric observations were made. Here the pressure on the sympathetic has paralyzed it, and the pupil contracts just as when the nerve is divided. This case beautifully demonstrates the fact of sweat fibres running in the thoracic and cervical sympathetic.

If we now look up the cases of sweating in the arm, it will be found that sweat fibres undoubtedly run in the nerves of that extremity. Thus, Case V.† A man æt. 38, had for five years a body the size of a pea, very painful, seated in the substance of the deltoid muscle, which was excised. After a year the pain returned in the same place, and in the succeeding three years the pains were unsupportable. These pains were continuous, but had irregular exacerbations lasting from five to ten minutes, when the pains sometimes ran toward the forearm to the fingers, and at other times in the vicinity of the supra-spinous fossa. The left arm is able to be used for strong effort, but is much weaker than the right. About two inches below the head of the humerus there is found a scar 1½ lines in extent, at whose lower end is a knot, extremely sensitive, and the size of a bean. By touching it a benumbing feeling is felt in the hollow of the hand where, as well as in the axilla, a large number of drops of sweat are to be seen, whilst the same neighborhood on the right side of the body is dry. Schuh considered it to be a tumor of connective tissue on the circumflex nerve. He excised the swelling with a small segment of the thickened nerve. The patient recovered but the sweating persisted.

In another case (VI.),‡ J. M., æt. 26. In May, 1866, the patient noticed a small tumor on the left humerus in the neighborhood of the ulnar side of elbow-joint, which was movable under the skin, and opened, since which time the skin was always moist and covered with a scab. Here the sweating was chiefly in the volar side of the forearm and the volar side of fourth and fifth fingers, and ulnar side of the third finger, whilst the remaining part of the arm was dry. Here the tumor involved the ulnar nerve and kept up a continuous irritation of the sweat fibres contained in it. These two cases leave no doubt that in the ulnar and circumflex nerves are found sweat fibres.

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* Bartholow.

† Nitzelnadel.

‡ Nitzelnadel.

As to inhibiting fibres, Schuh has noticed in two cases that after section of the frontal nerve of one side sweating was continuous in the parts supplied by the nerve.

REFLEX SWEATING.

I now shall give cases where sweating is a reflex act.

Case VII.—Dr. Pokroffsky reports : A patient, male, presented the following appearances whenever he began to eat: The right side of the face, the greater part of the forehead, a part of the region about the shoulder, and the entire neighborhood of the temple, the ear, a little strip behind the ear, and the upper part of the neck on the right side became decidedly red and covered with a profuse perspiration. This collected gradually in large drops and, if not wiped away, would run down over the body. The right half of the breast, the right arm and leg were, during eating, somewhat warmer and more moist than the same parts on the left side. During the perspiration the right temporal artery became prominent and pulsated markedly. Pulsation was also noticeable on the inner side of the cheek, the pupils contracted equally, there was slight asymmetry of the face and tongue, the right eyelid could not be raised quite as high as the left. During eating the temperature rose 0.2 to 0.4 C. in the right arm-pit, and other variations showed themselves later. Irritation of the sympathetic by the induced current during the patient's quiescence produced no effect similar to that brought on by eating, but if the patient began to eat while the stream was passing, the usual symptoms were observed. Faradization of the cervical sympathetic during eating caused rapid diminution of the red ness, and cooling of the right side. Various investigations were made, and showed the nervous system to be apparently normal. Electro-sensibility of the right cheek was diminished. The imperfect hearing was worse on the right side. There was enlargement of the liver and spleen, and the sweating dated back to a fever which was accompanied by parotitis of the right side.

Case VIII.—Mrs. H's child, when nursing at the breast, sweats at the knees—verified by the mother, an intelligent lady.

There are several cases on record where sweating ensues on one side of the face during eating. There seems to be in several of them a connection between four states: pre-existent parotitis, eating, sweating, and dilatation of the blood-vessels on one side of the face. What connection the parotitis may have I am unable to say, unless it has made the facial nerve more excitable, for this nerve when irritated calls out sweating in the face. The reflex circle here is the nerve of taste carrying sensory impressions to the medulla, which calls into exaggerated activity the sweat centres and the vaso-motor centres. In cats with cerebrum destroyed, electric irritation of the tongue brought out sweat in the anterior extremity.

ACTION OF MEDICINES ON SWEAT GLANDS.

Mr. G. B. Wood Field* and I have proved that muscarin calls the sweat secretion into activity by a peripheral action on the nervo-glandular apparatus. Since I have ascertained that when the sciatic has been divided for a week, and has completely lost all power upon electric irritation to call out sweat, the administration of muscarin will set the sweat glands into activity. Jaborandi under similar conditions has no power like this, although acting peripherally when the nerve is freshly divided. The inference is that muscarin and jaborandi act on different parts of the nervo-glandular apparatus. Atropin also retards the action of muscarin on the sweat glands.

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* *Journal of Physiology*, 1878.

RHYTHMIC FUNCTIONS.

When the spinal cord in the cat is divided completely at any height, the sphincter ani takes on a rhythmic movement similar to the diastole and systole of the heart. I have discovered that the sphincter vaginæ in the same animal and in the dog takes on a similar rhythmic movement when sections are made through the base of the brain from before backward; it is found that a section just behind the optic thalami is followed by a rhythmic movement of the sphincters. If, now, an irritation is made by the forceps of either the rectal or vaginal mucous membrane, one or both of the posterior extremities will set up a series of rhythmic movements, provided the spinal cord has been divided in the dorsal region. If, now, the spinal cord can set up rhythmic movements of the muscles, I cannot see why the rhythmic movements seen in man, of one of the extremities, are not due to either a central or reflex cause, acting on the central nervous system. Thus, the following case, reported by Dr. S. W. Mitchell, seems to me one where the nervous system has set up a rhythmic movement: "R. C., æt. 33; watch-case-maker; married, and has healthy children; no syphilis; his family history is bad—a sister, two aunts and his mother have had palsies in middle life; an uncle had epilepsy, and a cousin dementia. He was always nervous and excitable; used no spirits, smoked moderately, and was always well until the summer of 1865, when he was two days unconscious from sun-stroke, and has ever since been made weak by the heat of summer. About two years ago, in the summer of 1874, he observed that, while walking, the legs felt weak, and he was obliged to stop, as if to regain power, after which the right leg would drag for a time; at the same time he began to have pain in the back of the neck and lumbar spine. These pains continue. In Jan., 1875, he noticed a slight but increasing tremor in the left arm, and in two to three months the strange condition, which I shall try to describe. * * * * * * In sleep there was no movement; when he awakened he was conscious of the left hand being rigidly closed. In a few moments it began to twitch, the fingers moving as do those of a violin player. The slightest movement of any other limb, speaking or eating, even if he be fed, causes the left arm to execute a constant motion of striking the bed or his side, the limb being the while extended. When he arose and walked this action became more violent, and so much resembled the steady, rapid movements of a pendulum that I spoke of it at once to my assistants as a case of what might be called, descriptively, pendulum spasm. In fact, its rhythmic regularity was astonishing. Dr. Sinkler timed it on one occasion as 157; and on several others I found it always exactly 160. It was as accurate as the heart in its motions, but certain things always increased either the power or the number of the motions. * * * * * He has the power to stop the spasms by certain manœuvres. If he seizes the left hand with the right, and flexing the left arm, holds it, there is a kind of general spasm; the left hand, for a moment, seems to struggle with increasing violence; he totters, the face is convulsed; there is horrible pain in the back of the head. Then he gently releases the left arm, which, save for a slight tremor or twitching of the unquiet fingers, remains at rest, and may not move in violent spasm for an hour or more, and is sometimes nearly still for twelve hours." It has been found that the rhythmical movements of the sphincters can be arrested by an irritation applied to the sciatic. It would seem that, in the just described case, a sensory irritation (as grasping the arm) could arrest the rhythmical pendulum spasms.

VASO-DILATOR CENTRES.

That vaso-dilator nerves exist has been proved by the researches of many observers. Spinal vaso-motor centres also are quite generally admitted to exist. I have discovered that the skin of the pulps of the posterior extremities in the cat is innervated by vaso-dilator centres seated between the tenth dorsal and the first lumbar vertebræ. It seems to me that this fact will explain part of the symptoms in the cases in erythromelalgia described first by Dr. S. W. Mitchell. These cases must partly have a lesion seated in the spinal vaso-dilator centres. Dr. Mitchell describes the vasal symptoms as follows: "The next striking peculiarity of this disorder is the flushing of the part upon exertion. This symptom, which is usually absent in the very early stages, is a notable feature of the worst of the prolonged cases, and, in some mild instances, can always be brought on by great exertion of the foot. In the graver examples the area of greatest pain in the soles or hands is distinctly and permanently marked by a dull, dusky, mottled redness, as if the smaller vessels were always overdistended."

PATHS OF CONDUCTIVITY.

In the lateral columns of the dorsal region of the spinal cord of the cat run at least five kinds of fibres: sensory, motor, vaso-motor, sweat fibres and inhibitory. The vasomotor path was determined by making a section of the lateral column and observing the color-changes in the posterior extremity on that side, and comparing them with the opposite side. Of course the feet were unpigmented. The inhibitory fibres were traced by making with Woroschiloff's instrument sections of the cord, to different extents, and observing if the rhythmic activity of the sphincters took place. It was proved that the inhibitory fibres arose in the optic thalamus and passed down the lateral columns of the cord to inhibit the rhythm of the sphincters. Flechsig has shown that it is probable that fibres arise in the optic thalamus and traverse the lateral columns, but has not stated their nature. If, now, fibres running in the lateral columns inhibit the ano-spinal centre, it is highly probable that fibres inhibiting other reflex actions also exist. The exaggerated reflex seen in cases of spastic spinal paralysis may be explained in this manner: The sclerosis of the lateral columns, removing the inhibitory power coming from the brain, allows the spinal reflexes to come into activity.

VAGINO-SPINAL, ANO-SPINAL AND VESICO-SPINAL CENTRES.

The ano- and vagino-spinal centres in the spinal cord are located below the vesico-spinal. The existence of a vagino-spinal centre explains those cases of vaginismus where the peripheral irritation causes a spasm of the sphincter. The treatment of those cases is, to remove the peripheral lesion, and depress the reflex activity of the spinal cord. The vagino-spinal reflex also preserves, or rather supports, the uterus, by keeping the sphincter in a more or less continuous activity, thus antagonizing the downward tendency of the uterus.